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ABSTRACT

This research is part of a series of studies, in which the long term objective is to use computer-assisted instruction (CAI) to teach students how to solve nonroutine problems, i.e., problems in which the problem solvers must generate their own strategies. The subjects were 93 first and third graders who tried to solve a novel reasoning problem on a computer-based instructional terminal, in one of three conditions: experience only, feedback that was a visual record of the student's work on the first five problems, or interactive instructional feedback on how to solve each incorrect problem. Results showed that experience alone was as effective as the feedback conditions in terms of both the number of successful students and the number of trials needed to succeed. Successful students in all conditions generalized their strategies to two transfer tasks, but transfer was not immediate. It was hypothesized that in the initial task the feedback conditions failed because they did not enable students to eliminate their natural, but incorrect, strategies. Results of a post hoc study supported this hypothesis. (Author/MER)

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Experience VS Two Kinds of Feedback in CAI Problem Solving

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Paper presented at the Annual Meeting of the
American Educational Research Association

Boston, 1980

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ABSTRACT

Ninety-three first and third graders tried to solve a novel reasoning problem on a computer-based instructional terminal, in one of three conditions: experience only, feedback that was a visual record of the student's work on the first 5 problems, or interactive instructional feedback on how to solve each incorrect problem. Results showed that experience alone was as effective as the feedback conditions in terms of both the number of successful students and the number of trials needed to succeed. Successful students in all conditions generalized their strategies to two transfer tasks, but transfer was not immediate. It was hypothesized that in the initial task the feedback conditions failed because they did not enable students to eliminate their natural, but incorrect, strategies. Results of a post hoc study supported this hypothesis.

Experience VS Two Kinds of Feedback in CAI Problem Solving

Rationale and purpose.

This research is part of a series of studies, in which the long term objective is to use computer-assisted instruction (CAI) to teach students how to solve nonroutine problems. Nonroutine problems are the kinds in which the problem solvers must generate their own strategies. They are problems that cannot be solved by following a prescribed set of rules, such as those for adding 24 + 58. These are problems which cause difficulty for students of all ages, particularly those who are beginners in a subject matter area. Traditionally, there has been little effort to teach students how to solve such problems. In fact, we really do not know whether we can teach the necessary skills nor how to do so. I believe that these skills can be taught and that CAI has tremendous potential for helping us teach them. The purpose of my work is to figure out how to tap that potential.

In order to develop effective instruction, we must consider not only the logical processes that are necessary to solve the problem, but also the psychological processes of the beginner. They are frequently not the same. One of these differences is that beginners, unlike experts, do not take the time to formulate a solution strategy (Mosher & Hornsby, 1966) or they do only a limited amount of planning (Reif, 1977; Chase & Simon, 1975). They focus their attention on getting the answer, rather than on generating a strategy for getting it. They read the directions for a problem quickly and do not fully understand them, or worse yet, they skip them altogether (Bloom & Broder, 1950).

It seems reasonable, therefore, that an effective way to reach the students is to provide instruction as feedback, after they have tried to solve a problem and not succeeded. After experiencing some failure, they are more likely to attend to instruction. Furthermore, after some experience with the problem, they might have some better understanding of it. CAI is particularly well suited to provide such instructional feedback, and to do so for each individual student. The big question, then, is what kind of feedback to provide.

For this research, I chose two types of instructional feedback. Both were generated by extrapolating from research about feedback in written instruction (Kulhavy, 1977). My purpose was to compare them with experience alone, for helping children develop a solution strategy to a novel, nonroutine problem. One type of feedback, Record, was intended to allow the student to identify his own errors. The computer displayed on the screen the first 5 problems the student had done, along with his responses and whether they were right or wrong. The other feedback condition, Instruction, corrected the errors for the student. That is, the computer interactively helped the student do the problem correctly if he had done it wrong.

I was interested not only in whether the students could generate a strategy to solve the problems, but also whether they could then generalize their solution strategies to two other tasks.

Experiment.

Subjects. Participants were 57 first graders and 36 third graders. Third graders were included to verify that the problem was valid; that is, that it could be done by older children.

Materials. The experimental medium was PLATO. In the task, two 2-digit numbers and a third, covered one were displayed on the screen (Steinberg, 1980). The numbers differed in one position but were alike in

the other. The student was told that the covered number matched one of the uncovered ones. The task was to uncover (peek at) just one of the covered digits, and on that basis decide which of the numbers the covered one would match. The strategy, of course, was to uncover the discriminative part (right side, above). The computer was programmed so that the student could not get the correct match if the peek response was wrong. In addition, although it was obvious to the student on inspection if he had matched correctly, PLATO did not explicitly judge the answer for him. The student had to make that judgment himself (Steinberg, 1980). This task structure was employed in all conditions.

In the Record condition, PLATO judged the student's peek response. In addition, PLATO displayed at the top of the screen, the first 5 problems the student had done, along with the student's peek responses (Figure 1).

In Instruction condition, PLATO cleared the screen after an incorrect match and then repeated the problem, taking the student through it step by step. In this condition, too, PLATO judged the peek response for the student.

There were also two transfer tasks. One used different stimuli, pictures of common objects, and the other task employed 3, 3-digit numbers. Up to 99 different problems were available in the 2-digit task, and 30 and 60 in the pictures and 3-digit tasks, respectively.

Design and procedure. Each child was randomly assigned to one of the 3 conditions: Experience, Record, or Instruction. The sequence of events was: getting acquainted with PLATO, a discrimination test, the 2-digit, the pictures, and the 3-digit tasks.

In order to obtain a base line measure of students' abilities to solve the problem, all children did the first 15 problems in Experience condition. Then, if they had not reached criterion, they continued to do problems in their assigned condition until criterion (8 successive problems correct), or until they had done 99 problems, whichever came first. After the 2-digit task they did the pictures task, and then the 3-digit.

Children did the lessons on consecutive school days. In each session they worked until criterion in the task or until they became restless. Mean number of sessions was 9 per student; mean total time was 60 minutes per student.

Results. In the initial task, there were 19 first graders in each condition, with 14, 10, and 14 succeeding in Experience, Record, and Instruction conditions respectively. The numbers were not significantly different. All but one third grader succeeded. The proportion of successful third graders was significantly greater than of first graders ($\chi^2(1)=12.2$, $p=.005$). Further results will be reported for first graders only.

The last trial which the student did wrong, preceeding the 8 successive correct trials, is called the Trial of Last Error (TLE). Analysis of Variance of TLE's by condition and task showed a significant main effect of task ($p<.001$). Experimental condition was not significant. TLE's were 25.5, 8.9, and 11.2 for 2-digit, pictures and 3-digit tasks, respectively. TLE of 2-digit task was significantly higher than for transfer tasks; TLE's of transfer tasks did not differ significantly from one another (Duncan New Multiple Range Test).

Condition was not significant with respect to the number of children who solved each of the transfer tasks. Children who solved the 2-digit task also solved the 3-digit. However, only 28 of the 38 who solved the 2-digit also solved the pictures task.

Discussion.

Experience alone was just as effective by itself as feedback which also added a record of previous performance, or which told the student just what to do. It was not surprising that the record of previous work was not facilitative. In order to benefit from that feedback, the students had to infer why some answers were right and others were wrong. Since interviews revealed that first graders did not analyze why an answer was wrong, beyond the fact that they did it wrong, such a record did not provide useful feedback.

What was surprising was the failure of the Instruction condition to be better than Experience. The students were told exactly what to do. Even if they were just following the directions blindly, the succeeding trials were so much alike that they should have been able to do them correctly. However, the children had their own, albeit incorrect, strategy which conflicted with the one taught by PLATO. Initially, they were unable to overcome their natural inclination and sustain the correct procedure that had been taught. Just telling students what to do did not necessarily mean that they would accept the given method over their own. I made the hypothesis that in order to be successful, intructional feedback must also enable the student to understand the functional relationship between what he is doing and the goal he is seeking so that he will be willing to abandon his own strategy in favor of a correct one.

Another hypothesis that I made was that the student must be able to gain the insight into that relationship by himself; telling him may not be enough to accomplish that goal.

Once the child solved the initial task, the probability of solving the transfer task was not significantly different in the three conditions. Although children solved both transfer tasks significantly faster than initial task, they did not solve either of them immediately. One would have expected students to require one or two trials as warmup for the transfer tasks, but certainly not as many as 9 or 11. Interviews with the students revealed that in the 2-digit problems, they devised a strategy which was correct, but useful only for a 2-digit situation. They had to modify their strategy in order to solve the 3-digit problems.

Post Hoc Study

I did a post hoc study as a preliminary test of my hypotheses about instruction for solving this problem. Using the 3-digit task, I developed instruction which first helped the children understand the problem. I had previously observed that some of the children thought, for example, that the the digits that could be in the left hand part were the three digits of the left hand number rather than the left hand digit of each number. So, for example, if the numbers were 653, 624, and 651, some students thought

that the digits in the left hand part of the covered number could be a 6, a 5, or a 3 rather than a 6 or a 6 or a 6. The first thing the instructional lesson did was to require the student to explicitly state the digits that could be hidden under each part of the covered number. This was important not only for understanding the problem, but also for learning an important problem solving technique. That is, predicting the consequences of each of the alternatives, anticipating which digits could possibly be under each part of the covered number. As the student named them, these alternatives were displayed on the screen, and they remained there until the student decided which part of the covered number he wanted to peek at (Figure 2). At that point, PLATO showed the number that was actually under the part the student wanted to see, while the alternatives for the other parts remained on the display. They continued to remain on the display while the student decided which number the covered one would match. In this way the student could literally see for himself the results of his match, and could evaluate the results he would have obtained if he had chosen one of the other parts to peek at. Nine of the children who had previously failed the task did this lesson. Then they did the original 2-digit task in Experience condition. Seven of them succeeded and did so immediately, after an average of 2 trials.

Reference Notes

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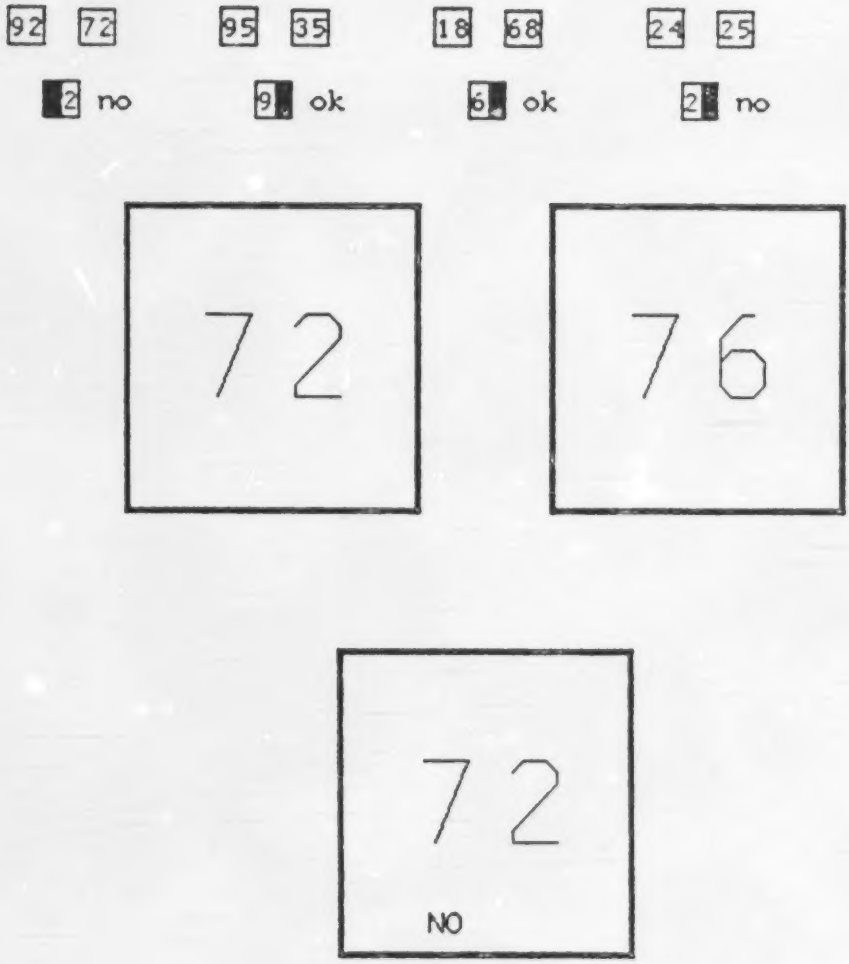
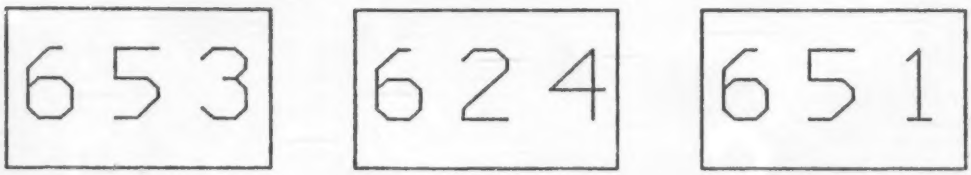
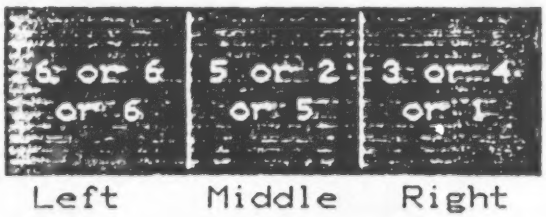

92 72
95 35
18 68
24 25
2 no
9 ok
6 ok
2 no
72
76
72
NO
Press Next
#5
Condition 1

Figure 1

One of these numbers is hiding under the cover.



What number did I hide?
You only need to peek at 1 box to know for sure.



Press NEXT.

Figure 2